UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Washington 25, D. C.

A REPORT ON THE SEDIMENTATION SURVEYS OF LITTLE ROCK RESERVOIR LOS ANGELES COUNTY, CALIFORNIA

By

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Special Report No. 6

Sedimentation Section
Office of Research

December 1943

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OF LITTLE ROCK RESERVOIR

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SYNOPSIS

Sedimentation surveys of Little Rock Reservoir, near Palmdale, Los Angeles County, Calif., were made by the Soil Conservation Service in January 1936, June 1938, and October 1943. This reservoir is the source of water supply for irrigation of about 2,500 acres in the Palmdale and Little Rock Irrigation Districts on the southwestern edge of the Mohave Desert.

From the date of its completion in April 1924 to the storm of February 27-March 3, 1938, the reservoir lost less than 2 percent of its original capacity of 4,217 acre-feet (at present spillway elevation 3250). This one storm brought into the reservoir approximately 480 acre-feet of sediment, causing loss of 11.38 percent of its capacity, and left an estimated 209 acre-feet of debris, in addition, immediately upstream from the reservoir.

Between June 1938 and October 1943 an additional 244 acre-feet of sediment has been deposited in the reservoir, causing a total capacity loss to date of 19.28 percent. Much of this material came from deposits left in the channel above the reservoir during the 1938 storm. Other material moving down the drainageways has replaced much of the sediment carried into the lake from this source, however. A large debris supply, extremely vulnerable to flood scouring, still exists and threatens additional capacity loss.

An investigation should be made to determine the most feasible methods of sedimentation control or of alternative water supply and storage.

INTRODUCTION

This report contains the results of sedimentation investigations by the Office of Research, Soil Conservation Service, at Little Rock Reservoir, located approximately 12 miles southeast of Palmdale, Los Angeles County, Calif. Surveys of this reservoir to determine reduction in storage capacity by silting were made in January 1936, June 1938, and October 1943, at the request of the reservoir owner, the Palmdale and Little Rock Irrigation Districts, and other agencies and persons concerned with the water supply for irrigation in this area. The report is issued at this time in order to supply information requested by interested agencies in connection with (1) a petition for a Soil Conservation District embracing the area irrigated by water from Little Rock Reservoir, (2) the planning of a soil and water conservation program, and (3) the planning for post-war water-supply improvements.

HISTORICAL INFORMATION

In 1892 the Little Rock Creek Irrigation District was organized to irrigate an area of 3,073 acres on the southwestern edge of the Mohave Desert, north of the San Gabriel Mountains in Los Angeles County. In 1916 the Palmdale Irrigation District was formed to irrigate 4,756 acres lying generally east of the Little Rock District. The lands of these districts are within a few miles of the point where Little Rock Creek emerges from its canyon on the north slope of the San Gabriel Range. The natural flow of Little Rock Creek was the original source of water supply for these districts. On the edge of the desert a cienaga, or swampy area, fed by the creek, yielded as much as 2-1/2 second-feet by pumping, during and after the winter runoff season, and its gravels yielded a limited quantity of water during the entire year.

In 1920, the two irrigation districts decided to jointly construct a storage reservoir on Little Rock Creek to insure a more adequate and dependable supply of water to meet growing irrigation needs. The Palmdale District voted $412,000 of 6% bonds which sold at 92-1/2. The proceeds were used to finance its share of construction of Little Rock Dam, for increasing the off-channel Harold Reservoir to 7,000 acre-feet capacity, and for extension of its concrete pipe distribution system. The Little Rock District sold $248,000 of 6% bonds at 95.

The contract for Little Rock Dam was let in June 1922, and construction was started shortly thereafter. The structure was completed April 1, 1924. The dam is reported to have cost $425,000. No. cost was incurred for land which is within the Angeles National Forest. Including ditches and flumes leading to the distributing system, the total cost of the Little Rock dam project was about $600,000.

The area irrigated by water from Little Rock Reservoir is at present approximately 2,500 acres.

THE DAM AND RESERVOIR

Little Rock Dam

Little Rock Dam is located about 3 miles upstream from the point where Little Rock Creek flows out of the foothills of the San Gabriel Mountains into the desert. The dam is a multiple-arch concrete structure, 724 feet in length, 170 feet in maximum height above bedrock, and approximately 115 feet in height above the original stream-bed level.

The dam has 29 buttresses which are spaced 24 feet apart on centers, and are 215 feet long at the bottom and 4 feet long at the top. The structure breaks about the middle at an angle of 15° 10'

from the downstream line of the dam to avoid carrying the foundation into a small but deep canyon on the upstream side. The upstream face has a 1:1 slope. The original spillway was a concrete siphon structure with a crest at an elevation of 3,260 feet above sea level. The siphon was separated into 16 divisions which had a combined discharge capacity of 13,000 second-feet. In 1935, a rough spillway was cut around the west end of the dam at an elevation of 3,250.97 feet to increase the discharge safety factor. After the heavy discharge of 17,000 second-feet during the March 1938 flood, an ogee spillway capable of discharging 22,000 second-feet was constructed by enlarging and concreting over the rock cut. The lowest of the step-like sills of this spillway has an elevation of 3,250 feet.

Two 24-inch drain pipes controlled by high pressure gate valves are located near the base of the dam. A 6-foot concrete pipe drop structure, topped by a wooden box screen, has been constructed above the outlet pipes to prevent their being silted over.

Reservoir Basin

The reservoir storage basin is in a typical reach of foothill canyon, which locally has nearly vertical walls, and elsewhere, as midway of the reservoir basin, has more moderate slopes of as little as 10 to 15 degrees. The original channel occupied nearly the whole of the valley bottom with little flood plain or terrace.

The original length of the reservoir, at the present spillway elevation 3,250 feet, was 6,700 feet, but this has been reduced to 5,100 feet by sedimentation. The greatest width is 1,200 feet about one-quarter mile above the dam. At the dam the width is about 700 feet, and near the original head of backwater it was only 200 feet. The original gradient of the stream through the reservoir area was 100 feet per mile or 1.9 percent. The original surface area at elevation 3,250 was 102 acres. This has been reduced to 88 acres in 1943.

THE WATERSHED

The watershed of Little Rock Reservoir comprises 68 square miles on the northern slopes of the San Gabriel Mountains, and is entirely within the Angeles National Forest. It is bordered on the south by the watershed of the West and North Forks of the San Gabriel River and by the Big Tujunga Creek watershed. On the east it is bordered by the Big Rock Creek watershed and small tributaries leading to Antelope Valley. On the west it has a common divide with the watershed of Solidad Creek and small streams draining to Antelope Valley.

The drainage area is about 15 miles in length and has an average width of 4.2 miles. Elevations vary from 3,250 feet at the dam to 8,214 feet on Mt. Williamson. Relief is highest in the central part of the watershed, averaging about 2,600 feet. The average relief for the entire area is about 1,650 feet. Slopes average about 35 percent for the watershed as a whole.

Little Rock Creek has a length of approximately 21.8 miles and an average gradient of 4.09 percent or 216 feet per mile, but from Little Rock Dam to the mouth of Cooper Canyon, 18.44 miles, the average gradient is only 2.58 percent, or 136 feet per mile.

The main tributaries have even steeper gradients. Santiago Creek, entering Little Rock Creek just above the original head of backwater in Little Rock Reservoir, has a length of 7.8 miles and an average gradient of 8.1 percent. The South Fork of Little Rock Creek, entering the main stream 7.4 miles above the dam, has a length of 5.5 miles and an average gradient of 4.87 percent.

The upper part of the watershed is underlain by the Lowe granodiorite, and the lower watershed by the Rubio metadiorite heavily injected by granodiorite. Both of these formations are highly fractured, and disintegrate rapidly by mechanical weathering. Soils are of the desert type characteristic of the northern slopes of the San Gabriel Mountains, consisting chiefly of disintegrated granitic rock residue, almost entirely lacking in humus.

The lower part of the watershed is sparsely covered by a pinon-juniper type of vegetation or by semi-desert chaparral. At higher elevations conifers of the pine and fir families are dominant.

The only recorded forest fire since 1878 was that of 1924 which burned about 4 square miles in the headwaters of the South Fork of Little Rock Creek.

A truck trail ascends the canyon from the dam to the headwaters on the South Fork. The road was washed out at a number of points during the March 1938 flood, but excavations for the narrow road were usually small, and it is doubtful whether an appreciable amount of debris was contributed from this source.

Stream Discharge

The The average annual runoff of the Little Rock Creek watershed at a gage 2 miles above the dam during a period of 9 years (1930-37 1939-41) was 14,987 acre-feet. The minimum runoff was 3,620 acre-feet in 1930-31, but in 1924-26 there was not enough flow to fill the reservoir, which had on original capacity of 5,300 acre-feet at elevation 3,260. The maximum recorded runoff was 51,620 acre-feet in 1940-41, but the total flow during the flood year 1937-38 was unmeasured. The area above the gage is 49 square miles, which includes most of the water-contributing area above the dam.

Stream flow is characteristically flashy. Cloudbursts are not uncommon. The maximum peak flow was estimated at 17,000 c.f.s. on March 2, 1938. In many years there is no flow from one to several months. Discharges by water years, recorded in U. S. Geological Survey Water-Supply Papers, are given in Table 1.

Table 1.--Runoff from Little Rock Creek

Water year	Total flow	Daily peak flow	Instantaneous peak flow
	Acre-feet	Second-feet	Second-feet
1930-31	3,620	195 (Feb. 4)	430 (Apr. 26)
1931-32	16,700	830 (Feb. 9)	2,200 (Feb. 8)
1932-33	4,170	56 (Mar. 9)	66 (Mar. 9)
1933-34	3,760	-----	455 (Jan. 1)
1934-35	22,750	1,210 (Feb. 5)	1,570 (Feb. 5)
1935-36	3,320	127 (Feb.23)	261 (Feb. 23)
1936-37	21,950	-----	1,550 (Feb. 6)
1937-38	------	-----	17,000* (Mar. 2)
Apr. 17-Oct. 1, 1939	3,270	-----	------
1939-40	7,000	174 (Jan. 8)	555 (Jan. 8)
1940-41	51,620	1,730 (Feb.21)	2,240 (Feb. 20)

*Estimated.

HISTORY OF RESERVOIR SURVEYS

A topographic survey of the Little Rock Reservoir basin on a scale of 1 inch equals 200 feet with 10-foot contour interval was made by the irrigation districts prior to construction of the dam.

In 1936, a survey of the reservoir was made during the period January 6-22 by a field party of the Sedimentation Section, Office of Research, Soil Conservation Service. No recoverable survey stations were shown on the original map, and it was necessary to establish a new triangulation control system and supplementary instrument stations. The storage capacity and sediment accumulation in the reservoir was then determined by the contour method of survey.1/ Five-foot contours were interpolated on the bottom of the basin from closely spaced soundings, and the 3250 and 3260 contours were mapped by plane table and stadia. This map was superposed on the original map by carefully matching the 3250 and 3260 contours. All control and instrument stations established in this survey were marked with numbered iron pipe set in concrete.

A second survey was made on June 28-29, 1938, by E. M. Flaxman and assistants, to determine the loss in capacity caused by the March 1938 flood. At this time the reservoir was nearly full of water. Soundings were located by the use of a transit which was set up on established survey points and oriented on other visible stations. Distance and direction of soundings from the instrument stations were obtained by reading angles and stadia to a rod held above the sounding line in the boat. The computed bottom elevations were plotted on the 1936 survey map, and contours were drawn by interpolation.

On December 10, 1939, E. M. Flaxman and the writer made an estimate of the volume of sediment in the canyon immediately upstream from and above the reservoir flow line by pacing and estimation of area of fill on cross sections.

On October 25-27, 1943, the writer, with assistants furnished by the San Fernando office of the Soil Conservation Service, made a resurvey of the sediment deposits to elevation 3250. Most of the previously established control stations were recovered and flagged, except for station 1006 which was found to have been destroyed. From this control, 10-foot contours were mapped by plane table and stadia on the surface of the exposed sediment. Soundings were taken in the small pool of water below elevation 3168, from which contours in the area next to the dam were interpolated.

The results of these surveys are shown on the reservoir map, Figure 1.

1/ Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bul. 524, Rev. by C. B. Brown, 168 pp., illus. 1939

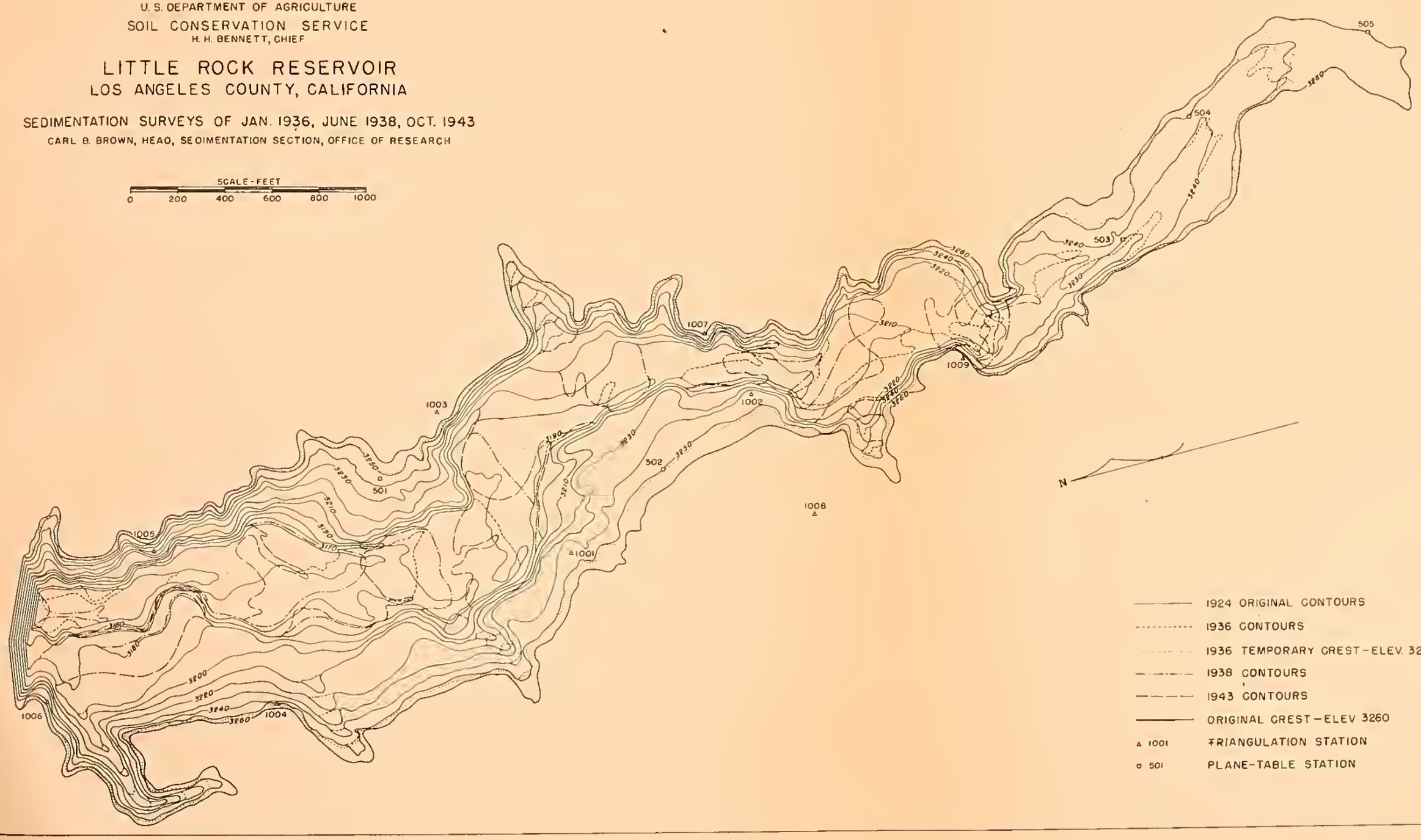
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF

LITTLE ROCK RESERVOIR
LOS ANGELES COUNTY, CALIFORNIA

SEDIMENTATION SURVEYS OF JAN. 1936, JUNE 1938, OCT. 1943

CARL B. BROWN, HEAD, SEDIMENTATION SECTION, OFFICE OF RESEARCH

SCALE - FEET
0 200 400 600 800 1000



1924 ORIGINAL CONTOURS
1936 CONTOURS
1936 TEMPORARY CREST - ELEV. 3250.97
1938 CONTOURS
1943 CONTOURS
ORIGINAL CREST - ELEV 3260
▲ 1001 TRIANGULATION STATION
o 501 PLANE-TABLE STATION

12-13-43

RESULTS OF SURVEYS

Capacity Loss

The progressive depletion of the storage capacity of Little Rock Reservoir is shown by the summary of data in Table 2, and the capacity curves, Figure 2. Table 3 gives data on areas, capacities, and sediment by contour elevations.

From the date of completion of the reservoir in April 1924 until the first sedimentation survey in January 1936, only 1.85 percent of the original storage capacity had been lost. This period of 11 runoff seasons included several years of subnormal runoff, but a flow of 2,200 c.f.s was experienced on February 8, 1932, and a flow of 1,210 c.f.s. on February 5, 1935.

Probably the total loss in capacity up to the storm of February 27-March 3, 1938, was not more than 2 percent. This one storm, which produced an estimated peak flow of 17,000 c.f.s or 250 c.f.s./sq. mile, and the subsequent residual runoff to July 1938, brought into the reservoir approximately 480 acre-feet of sediment, resulting in loss of 11.38 percent of the original capacity.

Furthermore, this flood left an estimated 209 acre-feet of sediment above spillway elevation 3250 and in the canyon immediately upstream from the reservoir. This material was left in a position to move down into the reservoir during succeeding flows of even relatively small magnitude. Large additional quantities of sediment were left in various reaches of the channels throughout the watershed, and this material likewise will move down into the reservoir in time.

Table 2.--Summary of sedimentation data on Little Rock Reservoir, near Palmdale, Los Angeles County, Calif.

	Unit of measurement	Beginning of storage April 1924	Survey of Jan. 1936	Survey of June 1938	Survey of Oct. 1943
Runoff seasons	Years	-------	11	14	19
Drainage area	Square miles	68.0	68.0	68.0	68.0
Reservoir:[1]					
Area	Acres	102	101	88	88
Capacity	Acre-feet	4,217	4,139	[2] 3,648	3,404
Capacity	Ac.-ft./sq.mi.	62.0	60.9	53.6	50.1
Sedimentation:[1]					
Total to date	Acre-feet	-------	78	[3] 569	813
Total since last survey	Acre-feet	-------	78	[3] 491	244
Annual to date	Acre-feet	-------	7.10	40.64	42.79
Annual since reservoir completion	Ac.ft./sq.mi.	-------	.10	.60	.63
	Cu.ft./ac.	-------	6.67	40.68	42.83
	Tons/ac. [4]	-------	.28	1.73	1.82
Annual since last survey	Ac.ft./sq.mi.	-------	--------	[5] 7.06	.72
	Cu.ft./ac.	-------	--------	[5] 480.44	48.84
	Tons/ac. [4]	-------	--------	[5] 20.42	2.08
Depletion of storage:[1]					
Total	Percent	-------	1.85	13.49	19.28
Annual	Percent	-------	.17	.96	1.01
Annual since last survey	Percent	-------	--------	[5] 11.38	1.16

1/ All data refer to present spillway level, elevation 3250.
2/ Extrapolated from capacity curve. Contour was mapped at temporary crest elevation 3250.97. Capacity at this level was 3,734 acre-feet.
3/ Not including an estimated 209 acre-feet of above-crest deposits.
4/ Based on assumed dry weight of 85 pounds per cubic foot.
5/ For March 1938 storm only, assuming 480 acre-feet was brought in by this storm out of 491 acre-feet between January 1936 and June 1938.

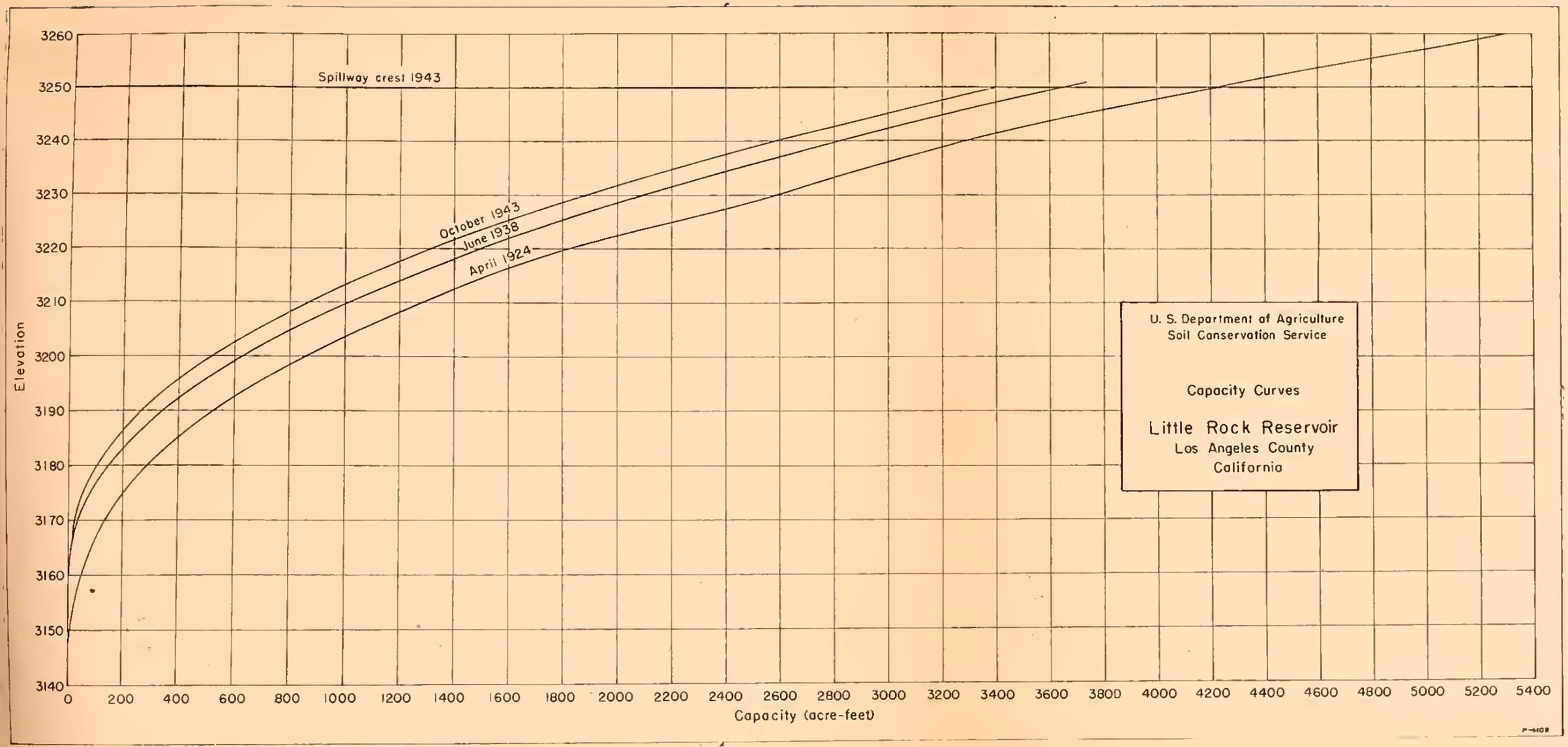

Spillway crest 1943
October 1943
June 1938
April 1924
Elevation
3260
3250
3240
3230
3220
3210
3200
3190
3180
3170
3160
3150
3140
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800
5000
5200
5400
Capacity (acre-feet)
U. S. Department of Agriculture
Soil Conservation Service
Capacity Curves
Little Rock Reservoir
Los Angeles County
California

Table 3.--Area, capacity and sediment, Little Rock Reservoir, Los Angeles County, California

Contour elevation	Area Acres				Capacity Acre-feet				Sediment Acre-feet		
	Orig.	1936	1938	1943	Orig.	1936	1938	1943	1936	1938	1943
3260	115.30	114.84	-----	-----	5,301	5,217	-----	-----	84	-----	-----
3250.97	------	101.92	89.20	-----	(4,315)	4,238	3,734	-----	77	581	-----
3250	101.55	100.94	88.20	87.63	4,217	4,139	(3,648)	3,404	78	569	813
3240	85.59	85.33	77.82	76.57	3,283	3,209	2,816	2,584	74	467	699
3230	72.59	72.19	67.24	62.77	2,493	2,422	2,091	1,889	71	402	604
3220	61.12	58.35	52.38	51.30	1,825	1,769	1,494	1,319	56	331	506
3210	47.70	45.42	43.66	39.97	1,282	1,251	1,015	864	31	267	418
3200	37.43	36.95	33.99	30.03	858	859	628	515	19	230	343
3190	29.03	28.84	23.32	20.55	526	511	343	264	15	183	262
3180	19.07	18.99	14.97	11.63	288	273	153	105	15	135	183
3170	11.60	11.26	8.82	5.62	136	124	35	21	12	101	115
3160	6.13	5.63	.26	.13	49	41	1	0.4	8	48	+48
3150	2.33	1.67	.00	.00	8	6	0	0	2	8	8
3140	.00	.00	-----	-----	0	0	0	0	0	0	0

The October 1943 survey showed that 244 acre-feet of sediment had accumulated since June 1938. Most of this material is believed to have come from deposits left in 1938 above the reservoir and in the canyons. Much, if not most of it was brought into the reservoir in the winter of 1940-41 when the total runoff was 51,620 acre-feet, nearly twice as great as in any preceding year for which records are available (excluding 1938). In this year the flow was sufficient to fill the reservoir more than 12 times.

A large amount of sand and gravel remains in the channel above the reservoir in depths of 5 to 10 feet on a grade of 0.8 percent, or more. Other deposits vulnerable to flood-scouring remain in the canyons at higher elevations. Regardless of the extent of further erosion on the watershed slopes, this channel material must be stabilized and prevented from moving downstream in the winter flows if the remaining capacity of the reservoir is to be retained for very many years.

Character and Distribution of Sediment

The delta deposits at the head of the reservoir, and for a mile upstream, consist of poorly sorted coarse sand and gravel. The sediment grades down the reservoir into fine sand, silty sand, and finally in the area near the dam, to dark gray to black silt with some very fine sand.

The thickness of deposits in various parts of the reservoir was determined in 1938 by plotting longitudinal profiles from the original, 1936 and 1938 maps. Near the dam the deposit was 17 feet thick, of which 2 feet was sediment deposited prior to the 1936 survey. The deposit 1,575 feet above the dam was 11 feet thick, of which 4 feet was deposited prior to 1936. At 2,400 feet above the dam, 2 feet of a 10-foot accumulation was older material, and at 3,210 feet, 7 feet of a 9-foot deposit had accumulated prior to 1936. This was part of a delta buried by recent deposits. At 4,200 feet, the accumulation was 15 feet thick, with 8 feet of material deposited in 1938. Twelve feet accumulated 4,800 feet above the dam, with that deposited prior to 1936 only 0.75 foot in thickness. At elevation 3250, 4,900 feet above the dam, 30.5 feet accumulated between 1936 and 1938.

CONCLUSIONS

For the first 12 years of its life Little Rock Reservoir suffered only negligible capacity loss. Runoff during the storm of March 1938 caused the most severe channel scouring and slope erosion ever observed in this watershed. The flood flow from this storm not only caused deposit of more than half of the sediment now in the reservoir, but left large quantities in channels above the reservoir. Future runoff no greater than during the first 12 years may be expected to produce silting 5 to 10 times as rapid as during that period.

Methods which should be considered for the control of silting are stabilization of channel deposits by debris dams; increased watershed protection by fire control, re-seeding, check dams, etc.; and removal of sediment by dredging or sluicing.

An investigation of the silting control and related water-storage and water-supply problems of the Palmdale and Little Rock Irrigation Districts should be made to determine the feasibility of various control methods.